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The Biology of Colias Butterflies. III. Variation of Adult Flight in the Arctic and Subarctic[1]

WILLIAM HOVANITZ, *Department of Biology, University of San Francisco, San Francisco 17, California*

Butterflies of the genus *Colias* frequently inhabit the same general geographical area. In fact, as many as five species may be collected in a few localities over an area not exceeding an acre. Extending this to one square mile, a total of six species may be found. Despite the existence of so many species in one place and their apparent general interfertility, the populations remain quite distinct, a fact which seems to be related (1) to their diet specifications, (2) to their microclimatic specificities, and (3) to differences in time of annual flight.

There are more species of *Colias* in the arctic regions than there are in the temperate areas of North America. This fact makes a comparison of flight differences between the species more effective in those regions. Most northern species must contend with a very short summer season so that they have time for only one adult flight during the season. A large portion of the season must be utilized for larval and pupal growth and development. A single seasonal brood is conducive to ease of comparing the times of brood emergence. Adult flights in the species with two or more broods per year tend to overlap, with consequent difficulty of analysis.

The period of the annual growing season during which the adult flight takes place is partly dependent upon local climatic conditions, and partly upon some differences about the species' own habits which as yet are mostly unknown. For example, *Colias eurytheme* Boisduval and *Colias philodice* Godart, both inhabit the Mono Lake Basin in eastern California. *Colias eurytheme* is

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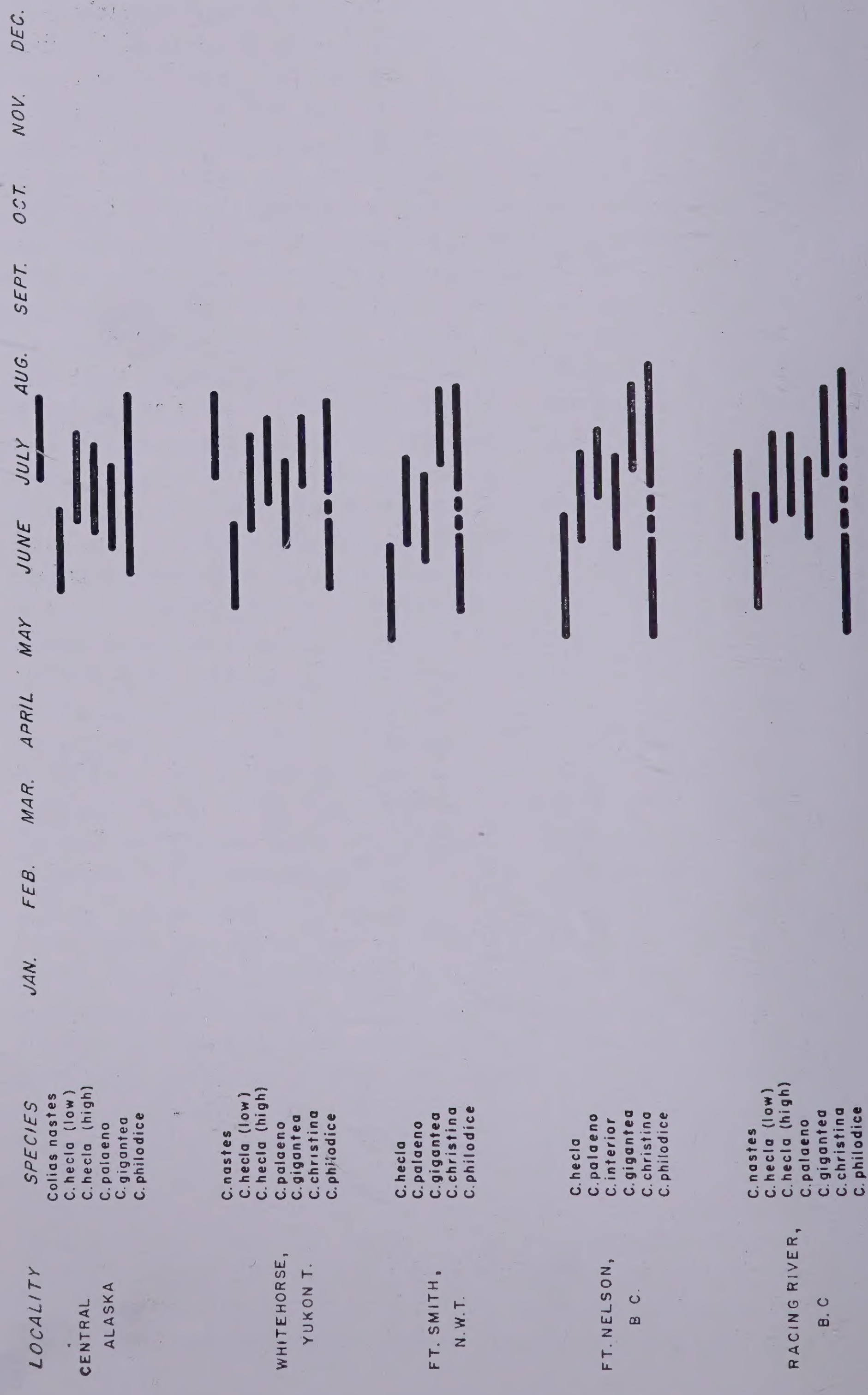
to be found there continuously throughout the non-freezing season while *C. philodice* is found only at two periods, May and July-August. The reason for the difference in this case is that *C. eurytheme* does not stop its breeding cycle at the onset of winter. It therefore is represented in the springtime by all stages of its life-cycle that have been able to survive the winter. *Colias philodice,* on the other hand, enters winter as third-instar larvae only, owing to an obligatory diapause which intervenes after the second generation. The first spring generation individuals therefore, having begun spring growth at the same stage, emerge as adults almost simultaneously. After laying eggs, the adults disappear and are not seen again until the second generation in July and August. When these disappear, no third generation appears at this locality for the species remains dormant in the larval diapause. *Colias eurytheme* does not have such an obligatory diapause, and thus is able to overwinter best in a southern climate. It seems highly probable that other comparable physiological differences between arctic species of *Colias* account for their variety of adult flight patterns.

Central Alaska.—Colias nastes Boisduval, appears as an adult later than all other species of this genus throughout the arctic regions and in the alpine environments of the northern Rocky Mountains. In central Alaska (specifically the Tanana River Valley) it flies only at elevations above timber line and there appears after the flight of *Colias palaeno* Linnaeus and that of the higher elevation form of *Colias hecla* Lefebre are half over (figure 1). At somewhat lower elevations (1–2,000 feet) the flight of the *C. hecla* is already past and that of *Colias gigantea* Strecker is nearly so. The flight of the second brood of *C. philodice* occurs simultaneously. At one locality on the Tanana River flats near Tok Junction both males and females of *C. gigantea* and *C. philodice* were very abundant about the first of July. Occasional females of *C. palaeno* were seen. At this point, the broods of the former two species coincided perfectly while it was apparent from the age of the *C. palaeno* females that the height of their flight was nearly over.

Yukon Territory.—At the valley elevations (2,000 feet) in the southern parts of the Yukon Territory, the flight of *C. hecla* is apparently maximum in the middle of June. Although this depends largely on yearly temperature conditions, the species' adult activity for the season of 1948 was as follows. For the month of June, the flight of the lower elevation *C. hecla* was nearly gone by the month's end. This coincided with the end of the first generation flight of *C. philodice* in the same area (figure 1). At about this time the first adult individuals of *C. gigantea* appeared and these continued to be present through the middle of July, after *C. hecla* had entirely disappeared. The second brood of *C. philodice* appeared about the first of July and the butterflies were virtually swarming by the middle of the month. Adults of *Colias christina* Edwards here were first apparent at elevations near 2,000 feet early in July and they were also swarming by the middle of the month. At higher elevations (5–6,000 feet), *C. palaeno* adults were fresh and in full emergence in the middle of July, together with fresh and abundant *C. nastes* and *C. hecla. Colias philodice* and *C. christina* were not seen above 4,000 feet in elevation.

St. Elias Mountains.—In the narrow strip between the Kluane Lake and the St. Elias Mountains only well-worn and occasional individuals of *C. hecla* were present at the lower elevations late in June. At this time a few males of *C. palaeno* were seen in the *Vaccinium* bogs and a few yellow *C. philodice* in dryer places. Early in July, *C. christina* adults began to appear at this locality and were very common by the middle of the month. In their habitat *C. gigantea* adults could be taken through the early part of July. At higher elevations (6–7,000 feet) in the middle of July, *C. hecla* adults were fairly common at the same time that *C. palaeno* adults were abundant at elevations of from 5–6,000 feet, *C. nastes* at elevations of 7,000 feet and up, and *C. philodice* below 5,000 feet.

Racing River, British Columbia.—A sequence of adult emergence as was apparent in the St. Elias Mountains area also exists in the Rocky Mountains west of Fort Nelson, along the valleys and canyons of and tributary to the Racing River. *Colias hecla* and *C. philodice* adults were very rare and well-frayed early in July at the lower elevations (2–3,000 feet). The former were quite fresh at elevations of from 5–7,000 feet about the middle of July and the latter swarmed during their second brood at elevations from 3–4,000 feet at the same time. *Colias gigantea* was never very common at this location, but seemed to be present occasionally in early July and possibly in late June. *Colias palaeno* adults were common in blueberry bogs (or tundra) at elevations of from 3–5,000 feet in the early and the middle parts


LOCALITY
SPECIES
JAN.
FEB.
MAR.
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
CENTRAL ALASKA
Colias nastes
C. hecla (low)
C. hecla (high)
C. palaeno
C. gigantea
C. philodice
WHITEHORSE, YUKON T.
C. nastes
C. hecla (low)
C. hecla (high)
C. palaeno
C. gigantea
C. christina
C. philodice
FT. SMITH, N.W.T.
C. hecla
C. palaeno
C. gigantea
C. christina
C. philodice
FT. NELSON, B.C.
C. hecla
C. palaeno
C. interior
C. gigantea
C. christina
C. philodice
RACING RIVER, B.C.
C. nastes
C. hecla (low)
C. hecla (high)
C. palaeno
C. gigantea
C. christina
C. philodice

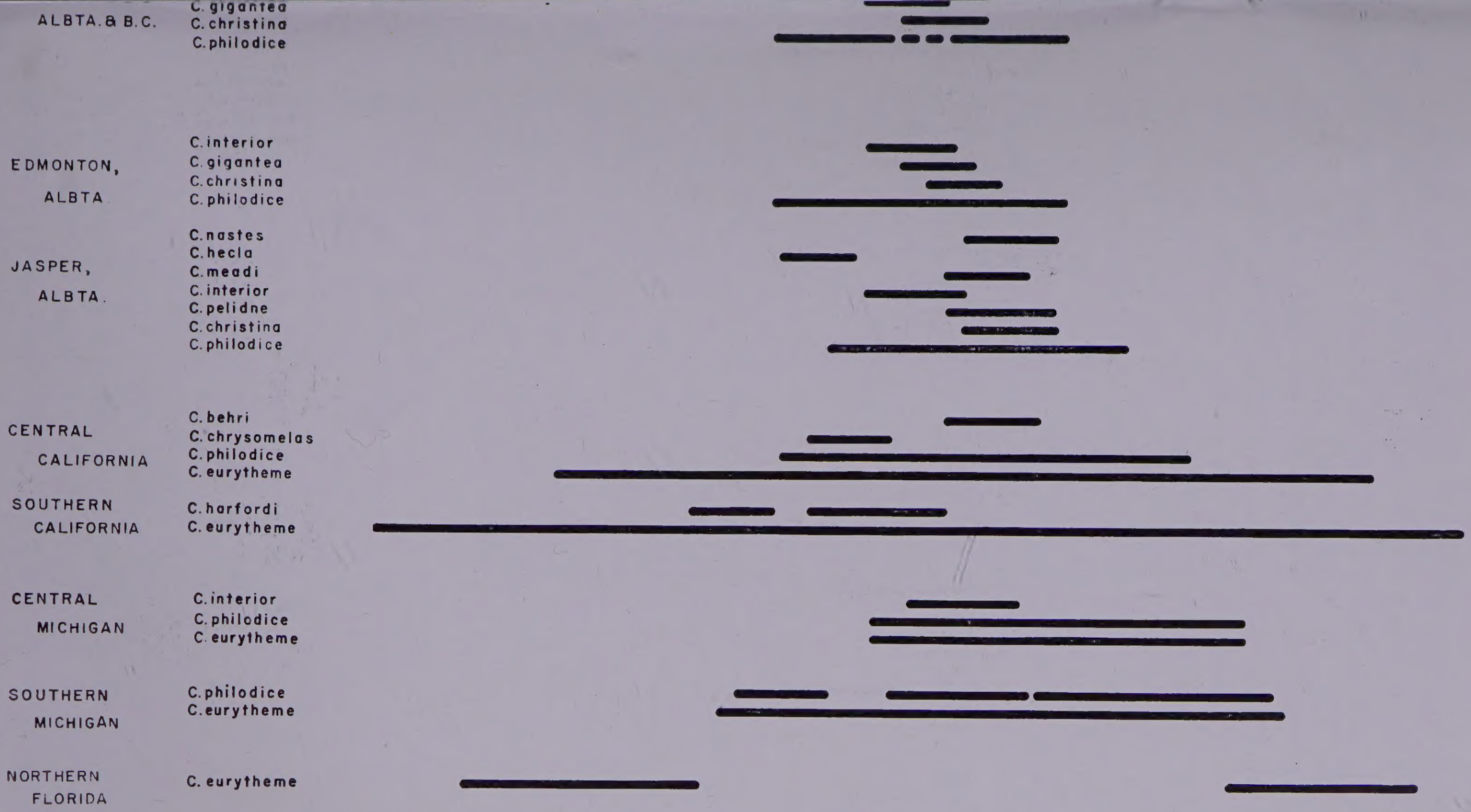


Figure 1. Chart showing the periods of adult flight of *Colias* butterflies in various parts of the arctic and subarctic areas as compared with species in the temperate parts of North America. Broken lines indicate probable interbrood periods when the number of adults flying may be absent or very scarce.

of July. After the first of July, *C. christina* adults became common below 3,000 feet and they swarmed on the river flats in the middle of the month. Above 7,000 feet the terrain was suitable for *C. nastes,* but only one frayed female was seen in the middle of July. The extreme aridity of this part of the mountain range during the year (1948) may have accounted for its early flight and scarcity. Farther south (Jasper) it is most abundant from the middle of July to the middle of August. Its presence in the mountains near Whitehorse, Yukon Territory, and in the St. Elias range at this time of the year, however, would indicate that the middle of July was the expected time for it at this locality.

Fort Nelson, British Columbia.—This locality is only one hundred miles east of the last considered, but is quite differently located, being on the low flat plain leading to the Mackenzie Valley, east of the Rocky Mountains. In general, the sequence of adult emergence is the same as at Racing River, but all species emerged somewhat earlier here in the year 1948 (figure 1). In addition to the species indicated for the latter locality, *C. interior* was found to be fairly common at elevations below 3,000 feet on the east slopes of the Rocky Mountains, often in company with *C. palaeno* and *C. philodice.* It is, however, somewhat later in appearance than *C. palaeno,* judging from the freshness of the adults. In sequence of emergence, *C. interior* is later than *C. hecla, C. palaeno,* and *C. gigantea* as well as the first brood of *C. philodice,* but it precedes the second brood of *C. philodice* slightly and *C. christina* considerably. It overlaps the flight of all species except *C. hecla,* but is generally not in common territory with any species except *C. palaeno* and *C. philodice* and then only in part.

Fort Smith, Northwest Territories.—East of Fort Nelson but in somewhat the same type of environment, the flights of the *Colias* butterflies can be interpolated from data obtained in 1947 at Waterways, Alberta; Ft. Smith, Northwest Territories; Yellow Knife, Northwest Territories; and in 1950 along the Hay River. *Colias hecla* occurs in its specific environments during the month of June along with occasional individuals of *C. philodice* belonging to the first brood. Early in July, the first brood of *C. philodice* and that of *C. hecla* have disappeared and adults of *C. gigantea* are quite common in willow bogs. Toward the middle of July, *C. gigantea* adults are replaced largely by those of *C. christina,* though there is some overlap of their broods. I have no personal evidence for the presence of *C. palaeno* in this area, but it does occur according to past records and probably can be found in local areas where its food plant, *Vaccinium uliginosum* appears.

Peace River Area, Alberta and adjacent British Columbia.—Three to four hundred miles south of Ft. Nelson and Ft. Smith in the Peace River District, the times of emergence of the species of *Colias* are only a little earlier in the year. *Colias christina* adults appear in late June, rather than in the middle of July and the flight overlaps that of *C. gigantea* considerably. *Colias interior* is also flying at about the same time, but is preceded considerably by *C. hecla* which latter species is recorded no closer than 100 miles north of the Peace River Area. *Colias philodice* has its two broods, the first occurring in May and early June, and the second in July and August.

Farther south, in the vicinity of Edmonton, the same species with the exception of *C. hecla* occur. Here there is a slight annual delay in emergence of *C. gigantea* and *C. christina,* but otherwise there is no difference between this area and the Peace River District.

Jasper and Vicinity.—The Rocky Mountains in the vicinity of the headwaters of the Saskatchewan and Athabasca rivers is the home of nearly all the species of *Colias* which are present farther north with *C. pelidne* replacing *C. palaeno* and with *C. meadi* in addition. *Colias hecla* is found at about 4,000 feet in elevation at the eastern foot of the mountains in May and possibly in early June. *Colias nastes* here does not fly with *C. hecla,* but is restricted to alpine elevations above 7,500 feet and flies from the middle of July to the middle of August. *Colias meadi* flies partly in the territory of *C. nastes* at about the same period. *Colias interior* is found locally at elevations up to 5,000 feet from the middle of June to the middle of July and is followed by its subspecies, *C. pelidne,* in July and August at elevations of from 6–7,000 feet. *Colias christina* occurs only below 5,000 feet in elevation and is most common in late July, contrary to its flight range farther north in the Peace River District in June. *Colias philodice* is present at all elevations up to 5,000 feet in two broods ranging from early June to August.

Other Arctic Localities.—Fragmentary evidence seems to indicate that in the far northern localities of Coppermine, Northwest Territories, and Aklavik, Northwest Territories, the sequence of adult emergence indicated by the data is similar to the above, but greatly overlapping. For example, *C. hecla* is still found earliest in the season (early July) followed immediately by *C. nastes* which greatly overlaps its flight range. In late July and early August these are followed by *C. palaeno.* The sequence apparent farther eastward at Fort Churchill on Hudson Bay earlier in the season is *C. palaeno* and *C. hecla* in the middle and late June and *C. nastes* early in July.

Comparison of Arctic with Non-arctic Localities.—Fewer species of *Colias* occur in the temperate parts of North America than in the Arctic. Four species from the central parts of California may be compared with a comparable westerly part of the Arctic. *Colias behri,* a representative of the *C. interior-pelidne* group, occurs at elevations over 9,500 feet in the Sierra Nevada. Here it is found in middle and late July and the first part of August. This compares with the period June to July for *C. interior* near Jasper, Alberta, at low elevations and July-August for *C. pelidne* at high elevations in the Rocky Mountains. The representative of the *C. christina* group in this region is *C. chrysomelas* which is found in late May and early June at sea level near the cool, but mild Pacific Coast. This compares with July and August for *C. christina* near Jasper. *Colias philodice* has a somewhat greater range of flight in eastern California than in the subarctic, being found from June to October, while *C. eurytheme,* not found at all in the Arctic, is to be found from early March until October or November along the coast.

In southern California, only two species of *Colias* occur: *Colias harfordi* H. Edwards, the representative of *C. christina* of the Arctic, is here double brooded. The first brood appears in April-May and the second in June. Aside from *C. eurytheme* and *C. philodice,* this is the only species or variety in North America known to have more than a single annual brood *(bivoltine* rather than *univoltine). Colias eurytheme* in southern California (south of the Tehachapi and the San Gabriel range) may be found in the fields any day of the year during which the sun shines. It is noteworthy that this is the only place outside of the Mexican and Guatemalan plateaux where the climate is suitable for *Colias* adult activity the year around.

In central Michigan three species are found. *Colias interior* is found during the month of July which, if at all different from the subarctic, is a little later in flight. *Colias philodice* flies here from June to October, a period duplicated by the sporadic *C.*

eurytheme. In southern Michigan, the first brood flight of *C. philodice* is of comparatively brief duration in May, the second brood in late June and July, followed by a third overlapping brood, extending well into October and early November in some years.

The seasonal pattern for *C. eurytheme* is similar to that of *C. philodice,* but it does not seem to be divided into definite broods.

Complimenting the flight of *C. eurytheme* in Michigan, this species is found flying in northern Florida in the months of February, March, and early April. This flight represents the first generation derived from a migratory flight of adults during the months of October or November. This species, the only one in Florida of the genus, does not seem to maintain itself for a longer period in the consistently warm and humid summer climate.

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